normal faults that dip eastward beneath Cache Valley, from north to south: the Clarkston, Junction Hills, and Wellsville faults (CF, JHF, and WF respectively; figure 1). Faults in three nearby areas may also be associated with the West Cache fault zone, but they have not been previously included because of a lack of demonstrable continuity with the fault zone and evidence for late Quaternary activity. Solomon (1997) mapped and discussed these faults, but did not find any conclusive evidence to clarify their relationship to the West Cache fault zone. The faults include, from north to south: the Dayton and Hyrum faults and several faults in the Mantua area (DF, HF, and MF respectively; figure 1). These faults are in bedrock, and Solomon (1997) found no evidence of displaced late Quaternary deposits.

Cache Valley is near the center of the Intermountain seismic belt (Smith and Sbar, 1974; Smith and Arabasz, 1991), a north-south trending zone of historical seismicity that extends from northern Arizona to central Montana (figure 2). Concentrated seismicity along this zone is coincident with a belt of faulting that forms a right-stepping en-echelon pattern from the northern Wasatch Range in Utah to the Yellowstone area in northwestern Wyoming (Machette and others, 1991). Three major active fault zones in this belt are in and adjacent to Cache Valley: the Wasatch, East Cache, and West Cache fault zones (figure 1). The Wasatch and East Cache fault zones trend through Brigham City and Logan, respectively, Utah's nineteenth and twelfth largest cities (1994 populations of 16,618 and 36,078, respectively); the West Cache fault zone is between these cities (figure 1). All of these faults displace the surface and show evidence of large earthquakes in recent geologic time, and thus they pose a significant seismic risk to citizens living in Cache Valley and northern Utah. Trenching to identify the size and timing of prehistoric earthquakes has been conducted on the Brigham City segment of the Wasatch fault zone (Personius, 1991; McCalpin and Forman, 1994) and East Cache fault zone (McCalpin and Forman, 1991; McCalpin, 1994), but no such studies have been previously conducted on the West Cache fault zone.

The Wasatch, East Cache, and West Cache fault zones all contain normal faults having mostly vertical and downward movement in the direction of fault dip. Surface displacement from a large earthquake on these faults may produce a near-vertical scarp (free face) in unconsolidated sediments, which rapidly erodes to a stable slope. Wallace (1977) and Swan and others (1980) recognized deposits produced by fault-scarp erosion and described the sequence of erosion and deposition. Erosion of the scarp forms a wedge-shaped deposit of colluvium (colluvial wedge) along the scarp base, burying the soil forming at the ground surface prior to the earthquake. Soil development ceases on the buried soil but continues on the colluvial wedge and degraded scarp. Each subsequent surface-faulting earthquake forms another colluvial wedge stacked on top of the downdropped surface soil, older wedge, and buried soil (paleosol). Earthquake timing can be constrained by determining the age of the paleosols and colluvial wedges. Paleoseismic studies along the Wasatch fault zone have used radiocarbon dating of organic-rich material in paleosols and colluvial wedges to define timing of past surface-faulting earthquakes (for example, Swan and others, 1981; Schwartz and Coppersmith, 1984; Lund and others, 1991; Personius, 1991; Black and others, 1996; and Lund and Black, 1998).

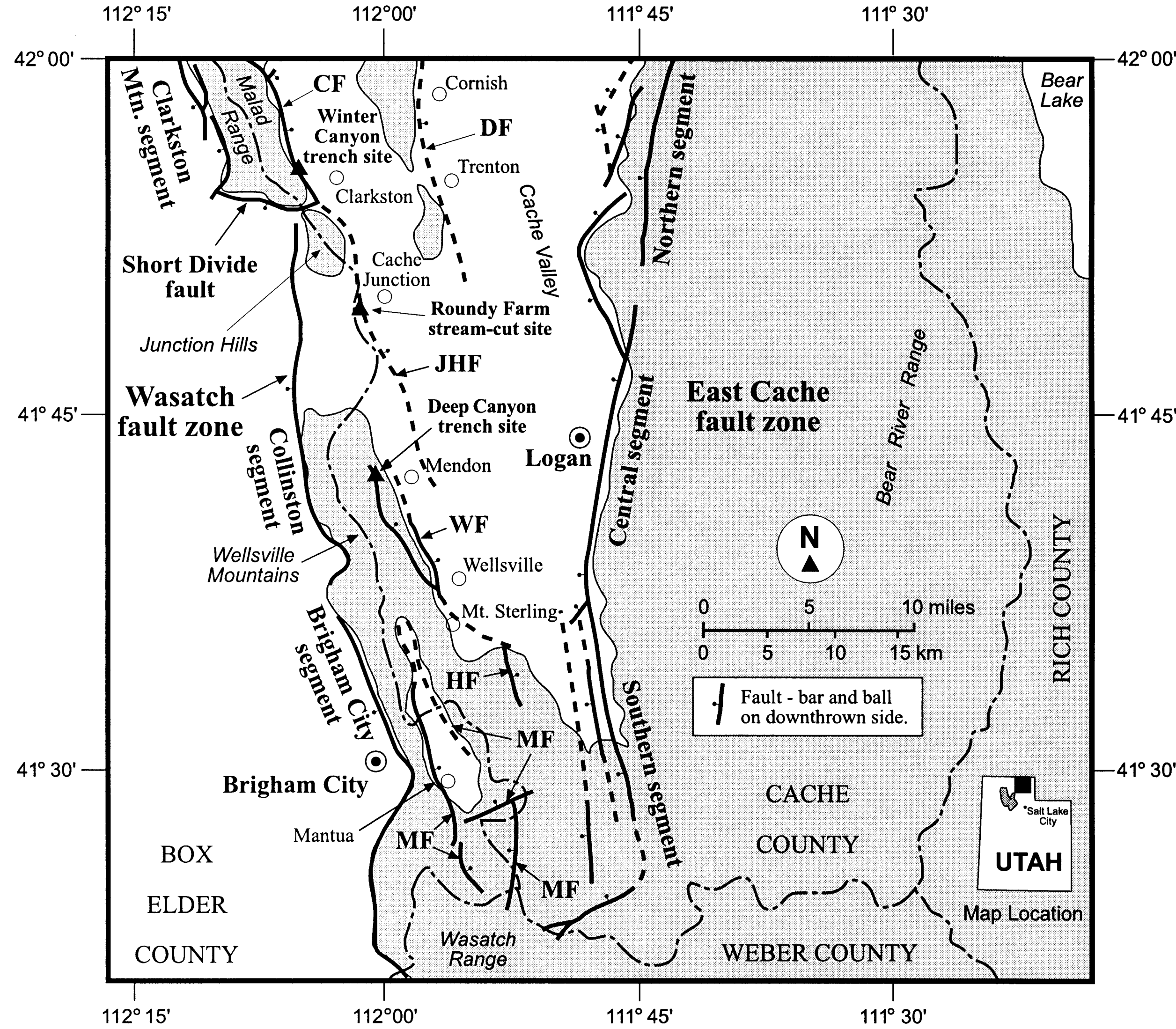

Figure 1. Location map showing simplified traces of the West Cache fault zone (WCFZ) and nearby faults (modified from Rember and Bennett, 1979; McCalpin, 1989; and Hecker, 1993). Faults in the WCFZ are: CF - Clarkston fault, JHF - Junction Hills fault, and WF - Wellsville fault. Nearby faults possibly associated with the WCFZ are: DF - Dayton fault, HF - Hyrum fault, and MF - faults in the Mantua area. Other nearby faults include the East Cache and Wasatch fault zones. Locations of our paleoseismic investigations are shown by solid triangles.

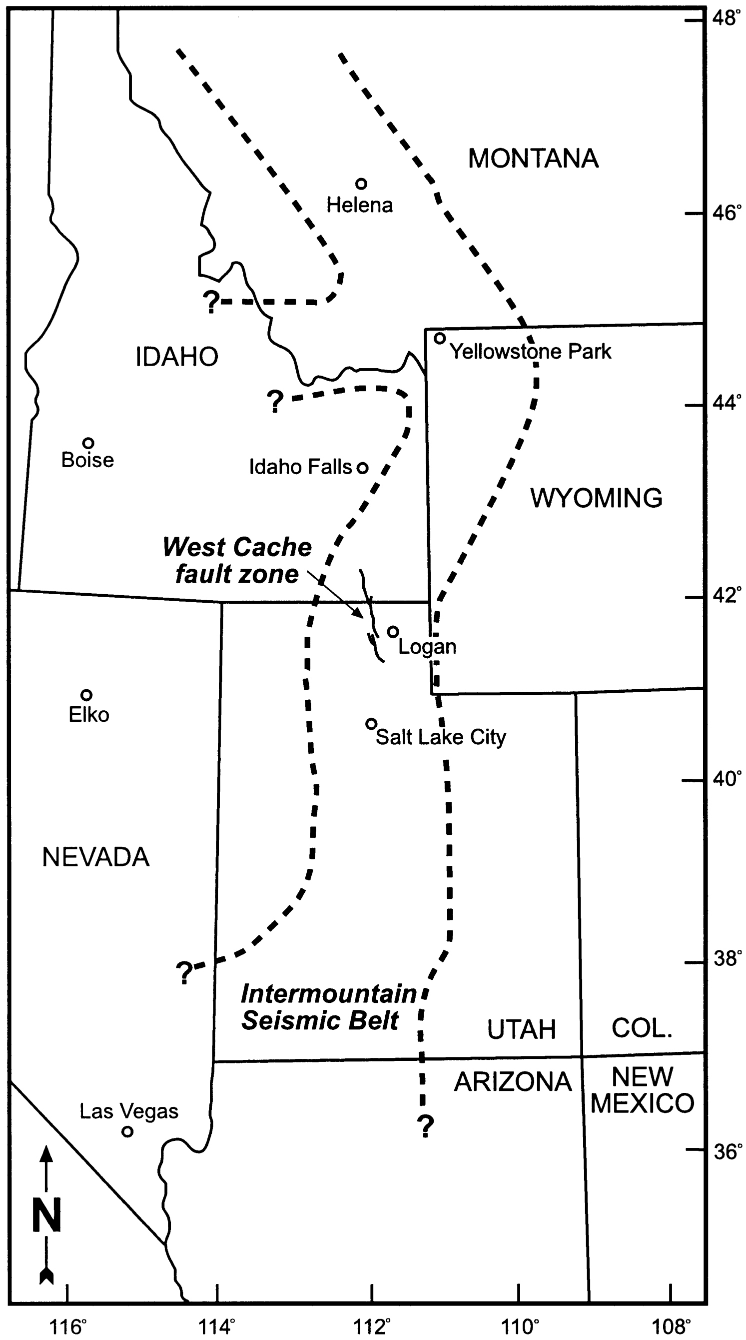

Figure 2. West Cache fault zone with respect to the Intermountain seismic belt (modified from Smith and Arabasz, 1991).

Late Quaternary geology of Cache Valley is dominated by deposits of Pleistocene Lake Bonneville. To correlate ages of events related to Lake Bonneville with our paleoseismic data, we estimated calendar-calibrated ages rather than use the radiocarbon ages commonly reported in the references. Calibrated ages are designated "cal B.P.", or just "years ago." The radiocarbon calibration curve of Stuiver and Reimer (1993) is based on studies of tree rings of known ages to about 11,500 years ago, and mass spectrometry of marine (coral) samples thereafter. Most Lake Bonneville ages fall in the marine portion of the curve, which is generally linear and lacks the cyclic age variability of the tree-ring portion. Don Currey (University of Utah Department of Geography, written communication, 1995) estimated various lake-cycle ages by multiplying the radiocarbon age by the slope (1.16) of a best-fit line to the marine portion of the calibration curve (rounding to the nearest century). This method provides a best estimate of ages of events related to the lake cycle (Don Currey, verbal communication, 1998; David Madsen, Utah Geological Survey, verbal communication, 1998).

The purpose of this study is to determine the West Cache fault zone seismic-source potential to aid evaluation of the earthquake hazard it presents to Cache Valley and northern Utah. The study included interpreting aerial photographs and previous surficial-geologic mapping (Solomon, 1997), profiling scarps and mapping two trench exposures across the Clarkston and Wellsville faults, mapping a natural stream-cut exposure of the Junction Hills fault, and radiocarbon dating. Paleoseismic parameters determined from the data include displacement per event and slip rate, timing of past surface-faulting earthquakes and recurrence, and estimated maximum paleoearthquake magnitude. The results provide new information on which to base future land-use decisions and manage seismic risk.

GEOLOGIC SETTING

Cache Valley is a north-south trending intermontane valley that is part of a structural transition zone between the extensional terrain of the Basin and Range province and the uplifted Middle Rocky Mountains province (Stokes, 1977, 1986). In Utah, the valley (average elevation 1,370 meters [4,495 ft]) is bounded on the east by the wide and rugged Bear River Range (maximum elevation 3,042 meters [9,981 ft]) and on the west by the narrow and sharp-crested Malad Range and Wellsville Mountains (maximum elevation 2,860 meters [9,384 ft]) (figure 1). The valley is about 80 kilometers (50 mi) long and 13 to 20 kilometers (8-12 mi) wide. The Bear River, the largest tributary of Great Salt Lake, meanders south through Cache Valley and exits the valley near the Junction Hills, which are found between the Malad Range and the Wellsville Mountains (figure 1). Several tributaries of the Bear River originate from the mountains surrounding Cache Valley, such as the Little Bear River, Logan River, Cub River, and Blacksmith Fork.

Structurally, Cache Valley is a narrow, elongate graben flanked by horst-block mountain ranges formed by movement on high-angle normal faults. To the west, the valley is bounded by the West Cache fault zone along the base of the uplifted Malad Range and Wellsville Mountains;